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ORIGINAL RESEARCH

IMMEDIATE AND SHORT TERM EFFECT OF DRY NEEDLING ON TRICEPS SURAE RANGE OF MOTION AND FUNCTIONAL MOVEMENT: A RANDOMIZED TRIAL

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ABSTRACT

Background: Dry needling (DN) has been established as an effective treatment for myofascial pain, however, there are no studies thus far investigating the benefit to movement and motor control.

Purpose: The primary purpose of this study was to compare differences in a series of outcomes between dry needling, dry needling and stretching, and stretching only in a sample of healthy males. A secondary purpose was to compare change over time.

Design: Blinded, randomized controlled trial

Methods: Thirty healthy male subjects were randomly assigned to one of three intervention groups: DN, stretching, or combination DN + stretching. Subjects in the DN group and DN + stretch group received DN to a palpated trigger point (TrP) in the triceps surae to elicit local twitch response. Subjects in the stretch group and DN + stretch group were instructed in a home stretching program for gastrocnemius and soleus muscles. All groups were tested for dorsiflexion range of motion and performed functional tasks (overhead deep squat, and Y-Balance test, Lower Quarter) prior to intervention, directly after intervention, and four days post intervention. Group comparisons were performed using a repeated measure Analysis of Variance and a partial eta squared calculation for effect size. For all measures a p-value of <0.05 was used to determine significance. Cohen's criteria were used to categorize strength of effect size.

Results: There were no statistically significant differences among groups for range of motion nor functional measures, with the exception of the deep squat. Proportionally, the DN group improved significantly in deep squat performance ($p<0.01$) compared to the other groups. Time oriented improvements were seen for the YBT posterior-lateral reach ($p=0.02$) only. Between groups effect sizes ranged from 0.02 (small) to 0.17 (large).

Conclusions: Including DN did not markedly influence range of motion nor functional assessment measures, excluding those seen during the overhead deep squat. Effect measures suggest the lack of significant findings may be an issue of statistical power.

Level of Evidence: 1b

Key Words: Deep squat, dry needling, range of motion, stretching, triceps surae

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INTRODUCTION

Dry needling (DN) is considered a safe and effective method to decrease pain and improve function by eliciting a local twitch response in the muscle of the myofascial trigger points (TrP). [1,2] Several recent studies have been published related to the role of dry needling and its benefits in treating upper quarter pain. Osborne and Gatt demonstrated that TrP dry needling was effective in reducing shoulder pain and improving shoulder function in elite female volleyball players.[3] Dry needling has also been shown to be an effective treatment for lateral epicondylitis as well as in patients with chronic shoulder impingement syndrome who had previously failed conservative management.[4,5] Following a recent meta-analysis and systematic review conducted by Kietrys et al, dry needling was recommended over sham or placebo, for decreasing pain immediately after treatment and for a duration of four weeks in patients with upper-quarter myofascial pain syndromes.[6] In addition, dry needling has been used in conjunction with traditional physical therapy interventions for treatment of adhesive capsulitis, resulting in significantly reduced pain and improved range of motion.[7]

Lower extremity pain and function have also been studied in relation to dry needling. Mayoral, et al reported that a single pre-surgical dry needling treatment of myofascial TrP under anesthesia resulted in a significant reduction in pain the first month after knee arthroplasty.[8] Furthermore, significant clinical improvements were demonstrated in pain, tenderness, and function when combining DN, eccentric loading of the hamstrings, and lumbopelvic stabilization exercises in runners with proximal hamstring tendinopathy.[9] Dry needling has also been reported as part of a multimodal manual therapy intervention for treatment of chronic femoral acetabular impingement that did not respond to prior surgical or non-surgical treatments.[10] More recently, the effects of dry needling in the lower extremities are being studied in the neurological population. Salom-Moreno et al found that a single session of dry needling decreased spasticity as well as widespread pressure pain sensitivity in subjects with spasticity post stroke.[11]

Although research surrounding dry needling continues to grow, the current literature focuses on addressing pain as the primary research outcome. There have been no studies specifically observing change in functional outcome measures following the intervention. At present, there are no studies that have specifically targeted triceps surae. The triceps surae complex includes both the gastrocnemius and the soleus muscles with attachments proximally at the posterior knee and distally at the posterior ankle. Restrictions in this muscle have been linked to knee pain, ankle/heel pain, and difficulty performing functional tasks such as squatting and lunging.[12] In addition, the triceps surae assist in control of the knee and ankle and thus, play a role in all lower extremity activities including walking, running, jumping and sports participation.[13-16] The presence of TrP is linked to overuse of muscles as well as inappropriate use of muscles.[17,18] In the present study, the triceps surae muscle was chosen to assess as it is used during exercise as well as daily activities and thus has a high likelihood of TrP presence. The purpose of this study was to compare differences in a series of outcomes in a sample of healthy males between dry needling, dry needling and stretching, and stretching only, when dry needling was targeted to the triceps surae. A secondary purpose was to explore the influence of time on outcomes. It was hypothesized that the individuals in dry needling and dry needling + stretch group would experience improvements in dorsiflexion measurements and squat patterns over the stretching group.

METHODS

Consort Guidelines: This study used the Consort guidelines for reporting of randomized trials. Refer to Figure 1 for flow of study enrollment.

Study Design: The study was a randomized controlled trial with three groups and equal allocation potential for each group.

Subjects: Healthy male subjects between the ages of 18 and 30 were recruited via word of mouth to participate in this study. To create a homogenous group of subjects, a single sex was recruited. Males were chosen for this study as evidence exists that males demonstrate more gastrocnemius stiffness than females when measured via shear wave elastography.[19] Individuals were included if they were healthy and physically active at least three times

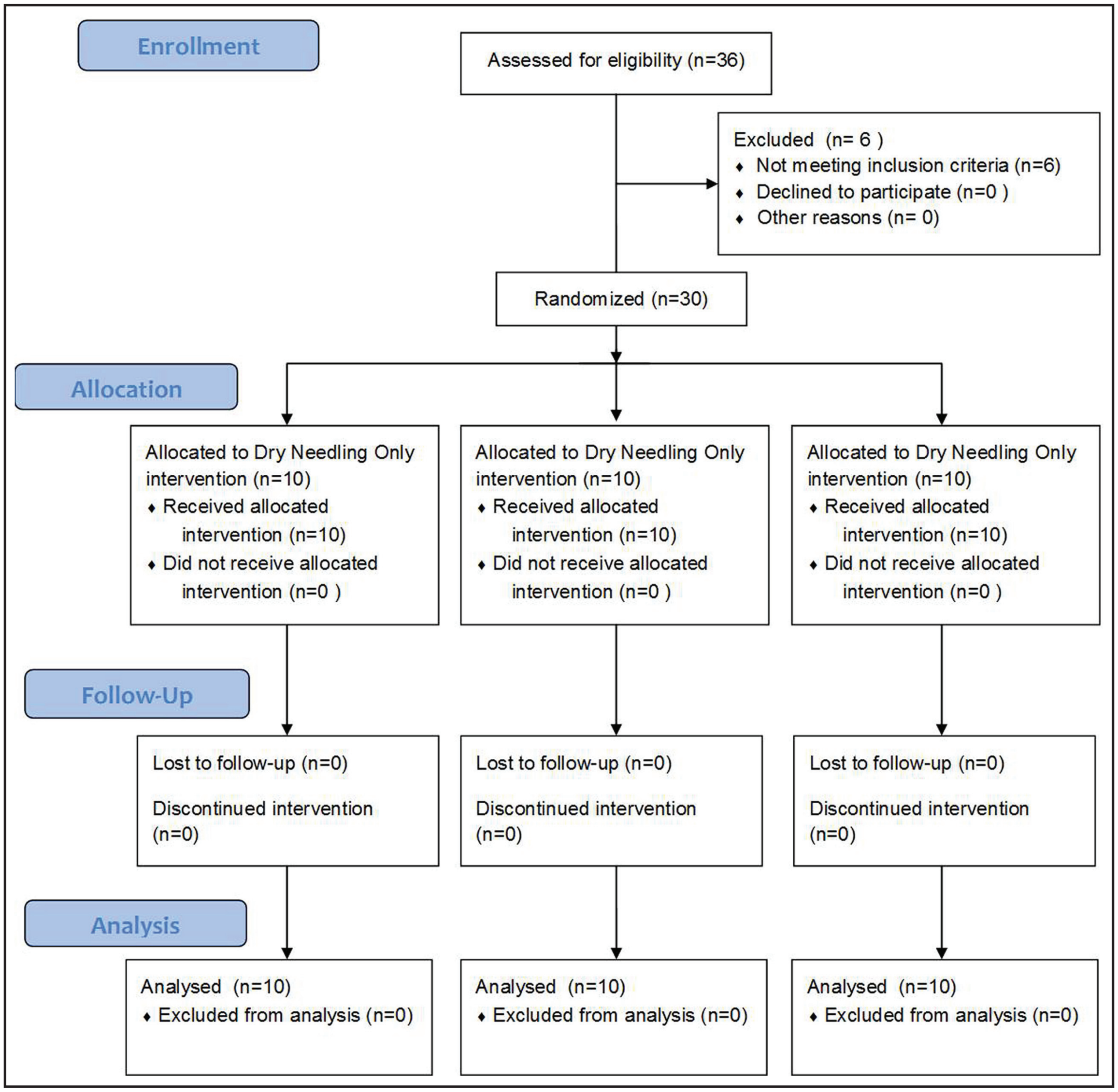

Figure 1. *Consolidated Standards of Reporting Trials (CONSORT) flow chart of study enrollment.*

per week for at least 30 minutes per bout of exercise (each subject completed a MARX Activity Questionnaire to quantify activity level (4 = least active, 16 = most active).[20] Subjects were excluded if they had a history of ankle surgery or were being currently treated for any lower body injury. Subjects were also excluded if they had any precautions for dry needling including: hypothyroidism, connective tissue disorders, chronic pain, bleeding disorders, taking anti-coagulants, active cancer, local or systemic infection, local skin lesion, local swelling/lymphedema, peripheral vascular disease including varicose veins, compromised immune system, and/or fear of needles.[21] All subjects signed an informed consent form that had been approved by the Duke University Health System Institutional Review Board prior to study initiation.

Sample Size: To determine sample size, the authors powered the study (a-priori) for all ten outcomes measures including pre-test, post-test and follow up periods. Assuming a normal distribution of the dorsiflexion measures and assuming an effect size of 0.67 (large) favoring both dry needling groups over the stretch only group, the authors constructed a sample size estimation using a repeated measure, analysis of covariance (RM-ACNOVA). Measuring between groups differences, with an expected 80%

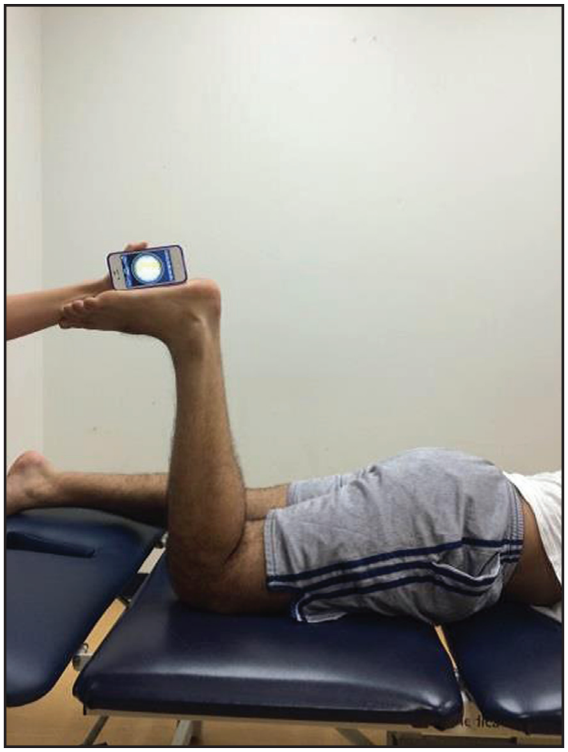

Figure 2. *Position of measurement for passive dorsiflexion.*

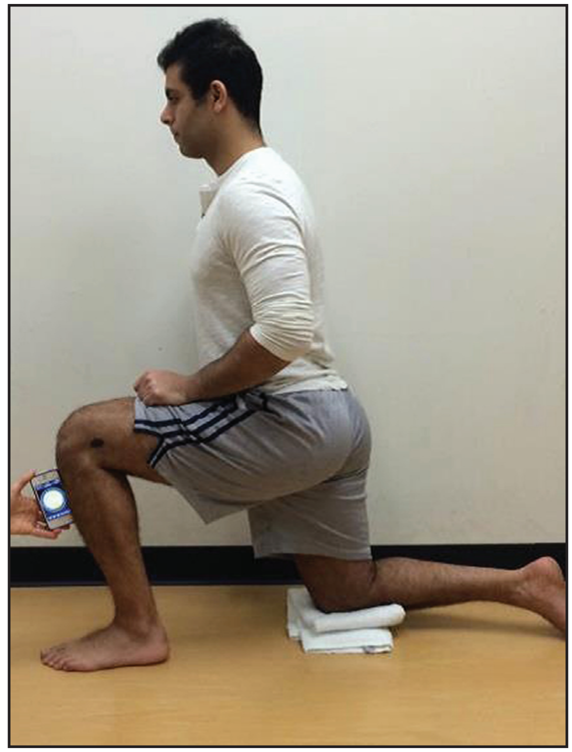

Figure 3. *Position of measurement for closed chain half kneeling dorsiflexion.*

power, 3 dedicated time intervals (including baseline), eight outcomes measures, three independent groups, and a standard error of probability of 0.05, it was estimated that the need for a minimum sample size of 30 for statistical significance (~10 per group). Further, the authorsid not oversample characteristics within each group for drop-outs.

Randomization Sequence: Subjects were randomly assigned via number generator to one of three treatment groups: 1) dry needling-only, 2) stretching-only, or combination dry needling + stretch.

Outcome Measures: The following outcomes were captured at baseline (pre-test), immediately after administration (post-test) and at a three day follow up: passive dorsiflexion (Figure 2), closed chain half kneeling dorsiflexion (Figure 3), closed chain (weight bearing) dorsiflexion (Figure 4), and deep squat[22] (Figure 5a-c). These procedures are described in Table 1. Also at baseline, post –intervention, and at the three day follow up, the Y-Balance Test of the Lower Quarter (YBT-LQ) was administered per the protocol described by Gorman to assess functional dorsiflexion and dynamic balance.[23] From these outcomes, the variables of interest were changes in DF

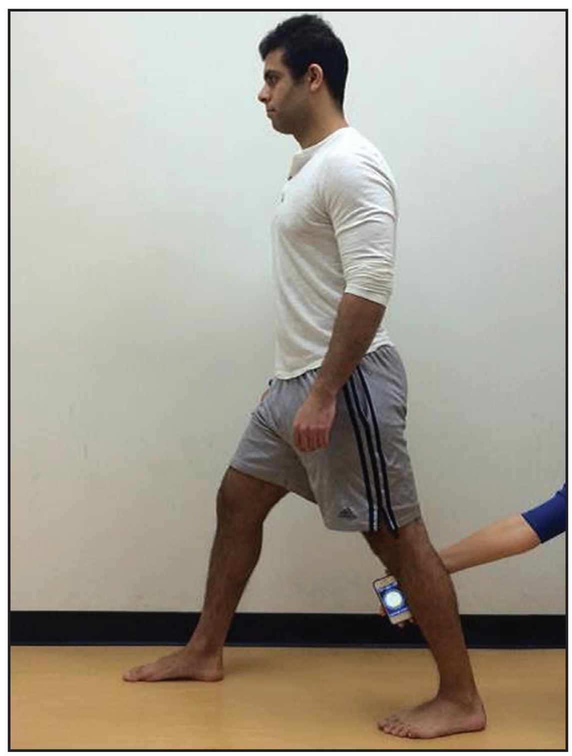

Figure 4. *Position of measurement for closed chain standing dorsiflexion.*

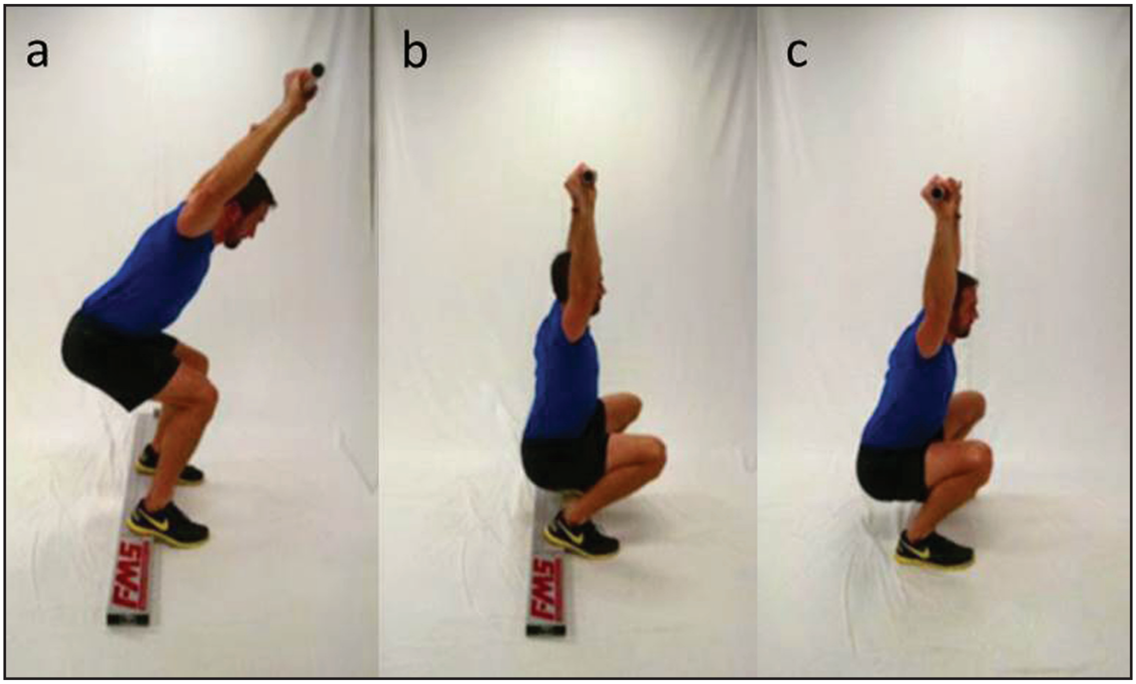

Figure 5. *The Overhead Deep Squat as described and scored by the Functional Movement Screen™. (a) Score of 1, (b) Score of 2, (c) Score of 3.*

Table 1. *Outcome measures and details of administration.*

Measure	Description of procedure	
Passive Dorsiflexion	The subject assumes a prone position with the leg being measured flexed to 90 degrees. The investigator passively dorsiflexes the foot to end range while maintaining a neural foot. An inclinometer placed along the 5th metatarsal measures the maximal dorsiflexion achieved. (Figure 2)	
Closed Chain Half Kneeling Dorsiflexion	The subject assumes a half kneeling. He is asked to lean his body weight forward as far as possible without lifting the heel. An inclinometer placed along the tibia of the forward leg, just distal to the tuberosity, measures the maximal dorsiflexion achieved. (Figure 3)	
Closed Chain Standing Dorsiflexion	The subject assumes a split stance position. He is asked to lean his body weight forward as far as possible without bending the knee or lifting the heel. An inclinometer placed along the tibia of the rear leg, just distal to the tuberosity, measures the maximal dorsiflexion achieved. (Figure 4)	
Deep Squat	As described by Cook, et al in FMS procedures.[22] Subject assumes a standing starting position with feet shoulder width apart and in the sagittal plane. A dowel is held overhead. He is asked to squat as deep as possible while maintaining an upright torso. If he can do this with the trunk parallel to the tibia, the dowel behind the toes, the heels down, and the hips below the knees he scores a 3. If he can perform this correctly with a heel lift, he scores a 2. If still unsuccessful, he scores a 1. If he has pain, he scores a 0 regardless of performance. (Figure 5 a-c)	

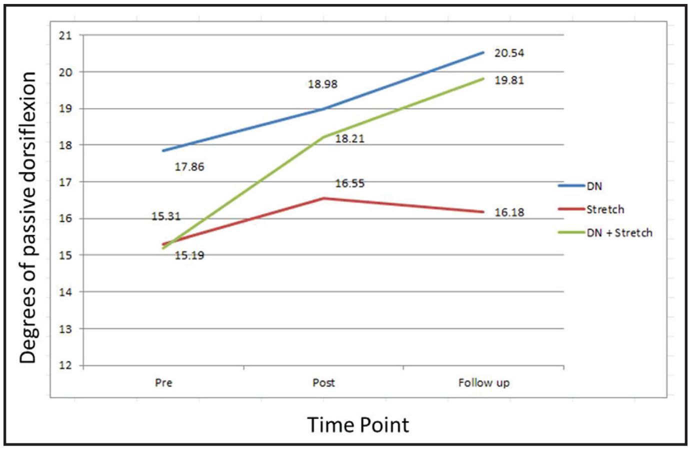

Figure 6. *Changes in dorsiflexion range of motion over time for each of the three groups.*

range of motion in the three described positions, the improvement in deep squat score, and the asymmetry between limbs for each reach direction and normalized composite score of the YBT-LQ. The physical therapists collecting outcomes were blinded to the treatment that each subject received and did not perform any interventions. Measures were collected bilaterally and later coded as "intervention side" and "non-intervention side" for all groups. In the stretch group, which included bilateral intervention, the side with the greatest DF restriction was chosen as the "intervention side" as this was the same criteria used to determine the side of intervention in the DN groups.

Interventions: Subjects in the DN group were positioned in prone and each gastrocnemius and soleus muscles were palpated for presence of TrP. The laterality of the intervention was chosen based on which limb demonstrated the most prominent trigger points as well as the most restricted passive dorsiflexion. The trigger point was assessed using the approach described by Dommerholt.[21] Once the location of a trigger point was established, each subject in the DN group received DN using a .30 x 5cm single-use-needle to the trigger point to elicit a local twitch response. The DN pistoning technique was performed as described in Trigger Point Dry Needling: An Evidence and Clinical Based Approach.[21] The single DN treatment was performed by the same physical therapist under musculoskeletal ultrasound which allowed for visualization of a local twitch response for each subject. Subjects in the stretch group (n = 11) were instructed in a home stretching program for gastrocnemius and soleus muscles. Subjects were instructed to stretch the gastrocnemius by positioning the back foot in a straight line with toes pointing towards the wall and leaning toward the wall with the back knee straight while keeping the heel on the ground. The same procedure was used for the soleus stretch with the exception of instructing the subject to bend the back knee when leaning forward. Each stretch was performed barefoot and was held for 30 seconds and repeated three times on each leg. Each subject performed the stretching program in its entirety at the test site and twice daily until the final follow up at four days post-intervention. Subjects recorded their compliance on a provided handout. The combination group received trigger point dry needling to triceps surae using the procedure listed above. They were then instructed to follow the same stretching program. DN was performed unilaterally to assess the central nervous system response. However, stretching was performed bilaterally to elicit a peripheral change. Immediately following intervention, all subjects were tested in the same manner as listed in the following paragraph. For blinding purposes, each subject, regardless of intervention group, was provided an adhesive bandage to wear during post-testing and was instructed to refrain from revealing which intervention he received. All stretches were performed bilaterally while dry needling was performed on a single side. All subjects returned after three days for re-testing.

Statistical Methods: Descriptive statistics were used to describe the healthy subjects across the three groups. A Repeated Measures ANCOVA was used to measure differences among times (post-test and follow-up), between the three groups (dry needling only, stretching only, and dry needling and stretching), and the group*time interactions among the unique multiple range of motion and functional outcome measures. The authors controlled for baseline measures of range of motion and functional scores. Partial eta squared, the effect size measure for an analysis of variance or covariance for between group changes, was calculated. According to Richardson and Cohen partial eta squared values of .0099, .0588, and .1379 represent effect magnitudes of small, medium, and large sizes, respectively.[24,25]

Because deep squat change scores were categorical, a Fisher exact test was used to calculate differences among groups at post-test and follow up intervals. A p-value of 0.05 was considered statistically significant. The categories were defined as the number of subjects who did improve and the number of subjects who did not improve across the three groups.

RESULTS

Thirty males participated in the study with no subjects lost to follow up. All subjects receiving the dry needling intervention were observed to demonstrate a twitch response via palpation which was visualized on musculoskeletal ultrasound. The groups required to stretch were one hundred percent compliant via the self-report home program documentation. Across the three intervention groups, the subjects were an average age of 26.41 $\pm$ 3.14 years and an average body mass index of 25.27 $\pm$ 4.36 kg/m^2. The median MARX Activity score was 10.0 (25, 75 quartile = 8, 13). There were no baseline differences across the groups in any category (Table 1).

There were no significant differences among groups for range of motion measures (Table 2). There were no significant differences between the two time points either. Further, no time*group interaction were found for any of the range of motion measures. Partial eta squared values ranged from a low of 0.05 (small) to a high of 0.17 (large).

Individuals in the DN group exhibited a significant improvement in performance of the overhead deep squat when compared to those in the stretch and the DN + stretch group at immediate post-testing ($p = 0.01$) and testing three days later ($p < 0.01$) (Table 3). There were no significant differences in performance among groups for YBT-LQ or range of motion measures (Table 4). A significant influence of time was identified for the physical function measure of YBT-LQ, posterior-lateral reach ($p = 0.02$) only. As with the range of motion measures, no time*group interaction for any of the functional measures were observed. Partial eta squared measures ranged from 0.02 (small) to 0.16 (large).

Table 2. *Subject Demongraphics.*

Group	Age (years)	Height (inches)	Weight (pounds)	MARX Score
DN	25.1 ± 2.4	70.3 ± 2.2	176.8 ± 23.8	10.4 ± 3.6
Stretch	27.1 ± 4.9	70.3 ± 3.2	192.5 ± 38.2	1.5 ± 3.3
Stretch + DN	23.3 ± 4.8	70.3 ± 8.3	175.8 ± 22.7	8.7 ± 4.7

DN= Dry needling

Table 3. *Squat outcomes among the three groups.*

Outcome	Groups	Immediate Follow Up	3 Day Follow Up	Within-Groups P value (Time)	Between-Groups P value (Group)
Squat	DN+Stretch	8=No change 1=change	0.01	8=No change 1=change	<0.01
	DN only	5=No change 5=change		4=No change 6=change	
	Stretch only	11=No change 0=change		11=No change 0=change	

Table 4. *Immediately post, and 3-day follow-up measures proxy measures of physical function (N = 30).*

Outcome	Groups	Immediate Follow Up	3-day Follow Up	Within-Groups p-value (Time)	Between-Groups p-value (Group)	Partial Eta Squared
YBT-Balance Composite Score (%)	DN+Stretch	100.53 (6.52)	100.52 (7.92)	0.10	0.31	0.08
	DN only	102.12 (4.78)	104.36 (7.13)			
	Stretch only	97.86 (6.48)	99.63 (6.64)			
YBT-Balance Anterior Reach	DN+Stretch	1.72 (1.54)	2.78 (2.51)	0.98	0.15	0.14
	DN only	4.23 (2.42)	3.83 (1.96)			
	Stretch only	4.54 (3.85)	3.18 (2.70)			
YBT-Balance Posterior-Lateral Reach	DN+Stretch	3.60 (3.76)	3.25 (2.17)	**0.02**	0.53	0.05
	DN only	3.72 (4.50)	3.72 (3.42)			
	Stretch only	3.72 (4.75)	5.31 (4.19)			
YBT-Balance Posterior-Medial Reach	DN+Stretch	4.60 (2.90)	2.80 (2.05)	0.32	0.08	0.17
	DN only	4.38 (2.51)	6.11 (5.64)			
	Stretch only	2.18 (1.00)	3.50 (2.58)			

DISCUSSION

This study examined both immediate and short-term effects of dry needling on DF range of motion and functional movement patterns in healthy individuals. The investigators hypothesized that both the DN and DN + Stretch group would have greater improvements in range of motion, dynamic balance, and functional squat over stretching alone. Although no statistically significant differences existed between groups for the majority of the outcomes, a higher proportion of individuals in the DN groups did improve in categorical scoring of the overhead deep squat. Further, for non-categorical measures, medium or large between group effect sizes in five of the seven non-categorical measures were identified.

Significant changes in the overhead deep squat score were present both immediately after DN intervention and at the three day follow up in comparison to the other two intervention groups. Changes were observed in the DN + S group, although these were not statistically significant. Although the study was powered using a RM ANCOVA and large effect, the authors feel that one of the reasons the study did demonstrate statistically significant differences is the sample size. Partial eta square measures the proportion of the total variance in a dependent variable that is associated with the effects of other independent variables and interactions are adjusted in the model. Similar to Cohen's D, which provides a magnitude measure of difference between groups, a partial eta squared is designed to provide an assessment magnitude of difference among the three groups in our study. Half-kneeling, YBT anterior and posterior-medial reach all yielded large effect differences between groups, descriptively favoring the DN group.

Interestingly, there were no subjects in the stretch only group that demonstrated change in deep squat score. The deep squat requires bilateral functional dorsiflexion yet this improved in the DN group and to a lesser extent the DN + S group, both of which received unilateral intervention. This may be attributed to the neurophysiological response of the spinal reflex that occurs during dry needling when twitches are elicited, thus enabling bilateral effects from a unilateral treatment. It has been established that TrP, both active and latent, affect movement via muscle activation patterns.[17,26] In addition, dry needling of a myofascial trigger point is effective in diminishing spontaneous electrical activity of that point if local twitch responses are elicited.[27] When spontaneous electrical activity of the muscle is diminished a more normal muscle state is achieved. Authors have also shown that latent trigger points provide nociceptive input to the dorsal horn even when they are not spontaneously painful[9] which may explain the observed changes in functional movement patterns following dry needling.[28,29]

DF ROM has been linked to performance of functional tasks. Prior studies have shown limitations in dorsiflexion, as measured in weight bearing, as an indicator of decreased performance.[30,31] Rabin et al assessed DF range of motion in a lateral step-down test among healthy males[30] and found association between ankle DF range of motion and movement quality among men. More specifically a 'good quality' movement pattern, as seen during the lateral step-down test, indicated greater DF range of motion. Thus, it is likely that multiple factors influencing DF range of motion can also affect weight bearing movement patterns. Kang et al further confirmed that functional performance may be altered with limitations in DF, as determined by the weight bearing lunge test. Specifically, the anterior reach distance on the lower quarter Y-balance test was significantly correlated to DF measured via the weight bearing lunge test.[31] Thus, one can infer that ankle kinematics can affect performance during weight bearing tasks. In the current study, subjects did not demonstrate significant improvement in composite score or reduction in reach asymmetry with the exception of the posterolateral reach direction which showed improvement over time. With a larger sample size, significant changes in anterior reach, posteromedial reach, and composite score performance may have been observed as the effect size for both anterior and posteromedial reach distance was large.

There were several limitations to this study. First, this study enrolled healthy subjects rather than a patient population thus limiting potential application to the typical clinical setting. Also, these subjects did not demonstrate significant restrictions in initial ankle dorsiflexion range of motion (where normal range is between 0-16 degrees in non-weight-bearing and up to 34 degrees in weight bearing).[32] Thus, the investigators, were not fully able to appreciate the influence DN may have on limited DF. Second, the mechanism causing dorsiflexion end range of motion was not determined. So, it is unknown if the restrictions were due to tissue extensibility or joint restrictions. Future research may compare groups with and without dorsiflexion restrictions and the effect on functional movement patterns pre and post dry needling.

In addition, studies with longer follow up are needed to establish long term benefits of dry needling compared to dry needling/stretching combination or stretching programs alone as the current study's follow up ended at three days post intervention. The current study included only a single dry needling treatment, as is typical in clinical practice, rather than three consecutive days of dry needling treatment. Additional dry needling sessions, matching the frequency of the prescribed daily stretching sessions, may have yielded different results. Future iterations of this study should employ shear wave elastography to observe and objectify changes in trigger point size pre and post DN. Furthermore, research is needed to establish long term maintenance of changes in functional movement patterns that may have been affected.

CONCLUSION

Dry needling to an identified TrP in the triceps surae in healthy males resulted in both immediate and short-term changes in the overhead deep squat pattern. Including DN did not markedly influence range of motion and functional assessment measures, apart from the squat. Effect sizes suggest moderate to large effects from the DN treatment despite the lack of statistically significant differences, meaning some results may be due to insufficient power.

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